# TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE BOISE, IDAHO SOIL CONSERVATION SERVICE

February 4, 1982

TN - BIOLOGY NO. 7

The following information, developed by S. K. Johnson, Extension Fish Disease Specialist, was furnished to SCS by the Fish Disease Diagnostic Laboratory, Texas Agricultural Extension Service, Department of Wildlife and Fisheries Sciences, Texas A&M University System, College Station, Texas. It was distributed for use in assisting commercial fish producers as well as small recreation or farm pond owners who wish to transport live fish.

## TRANSPORT OF LIVE FISH

During transport of fish, maximum care is needed to avoid deaths or conditions that would cause fish to die.

### METHOD OF TRANSPORT

Damp (no water). Eggs and adult fish of some species are transported in ice-chilled, humid chambers. In the Southern U.S. out-of-water transport of fish has not been generally practiced.

Tank (air supplied). In this method, a vehicle-mounted tank is used. The replenishment of oxygen is supplied from air and aided by various methods of surface agitation, from bubbles of air introduced through holes in air pipes in the tank bottom or from pumping water out and spraying it back into the tank.

Tank (pure oxygen supplied). This method is popular among fish farmers. Fine bubbles of oxygen are released from airstones or finely perforated plastic pipes at the bottom of the tank. As the bubbles rise, they replenish oxygen. Although this method is more costly, there is less chance of mechanical failure. The liquified state is less expensive than the compressed gas and allows for a large supply in less space.

Bag. Transport of fish in plastic bags is a world-wide practice. Bags are partially filled with water and fish are added. Oxygen is supplied from a compressed oxygen cylinder to fill the remainder of the bag. The bag is then closed with a sealing device such as a rubber band.

### EQUIPMENT

Transport equipment is varied. Wood, fiberglass, aluminum and galvanized metal are utilized in construction of hauling tanks. Various types of transport units are commercially available. Sizes and shape of tanks vary but the methods of replenishing oxygen are rather standard - agitators, blowers, compressed gaseous oxygen and liquid oxygen.

Agitators. An agitator is basically a mechanical stirring blade covered with screen to protect the fish. The blade extends partially into the water and rotation produces much air exposure to the water and current throughout the tanks.

Blowers. Blowers sometimes are used on large tanks. Air from the blower is directed through pipes to the bottom of the tank where it is released as bubbles through perforations in the piping. Blowers often are used in combination with agitators.

Compressed gaseous oxygen. This method is rather simple and utilizes a standard compressed gas bottle fitted with a medical-type regulator. This method normally is used when small batches of fish are transported. A tube from the regulator extends to the bottom of the tank where a perforated tube or airstone is attached. The oxygen is absorbed better when released in the deeper water. A large spacial distribution of bubbling points and greater volume of release also aid in efficiency.

Liquid oxygen. The use of liquid oxygen is becoming a more accepted method in transport. Like compressed gaseous oxygen, there is an advantage in avoiding problems with mechanical failure. In addition, the equipment is lighter than for gaseous oxygen and the cost of oxygen is less. Liquified oxygen is packaged in a different container than gaseous oxygen but when it comes out of the container it is transformed into the gaseous state. The release is typically through perforated piping in the tank bottom.

A sturdy bag with 4 mil (1 mil = 0.001 inch) thick plastic is preferred for bag transport. For ease in filling bags with oxygen, the oxygen regulator is fitted with a flexible rubber hose of suitable length. Folds which form pockets and trap fish can be avoided by careful packing. A box with suitable dimensions aids in avoiding pockets. Insultated packaging often is used to control temperature. Ice is placed in the packaging to maintain cool water. Avoid having lighted cigarettes or other burning objects near the plastic bags because the oxygen will ignite if a spark drops on the bag.

## REQUIREMENTS AND LIMITING FACTORS

Oxygen. Water has a low capacity for oxygen. Consequently, water low in or depleted of oxygen is the primary problem in fish transport.

In water provided with an unlimited amount of oxygen, a fish at rest will consume a minimum amount of oxygen. In a fish transport system, the fish will require more than the minimum amount since they are not at rest. Furthermore, if they are excited at loading or disturbed during transport, they may consume near the maximum amount.

The amount of oxygen a fish consumes also depends on the amount of oxygen available. At high levels, the fish will consume at a steady rate. When water oxygen levels are low, fish consume lower amounts of oxygen than when oxygen levels are high despite the degree of activity.

Fish transport systems often contain water with oxygen levels that do not provide enough oxygen required to satisfy the fish bodies. To offset this predicament, the fish will shift its metabolism to use the "stored" oxygen of the body. This condition is likened to that of a man who is at rest suddenly performs strenuous activity before a proportionate amount of oxygen is taken in. For the man and the fish, an oxygen "debt" is created which must be repaid when favorable oxygen conditions are experienced.

The first hour after loading is a particularly critical time for fish in respect to their oxygen needs (Figure 1). They are excited and require a large amount of oxygen with a short time for adjustment.

Oxygen requirements are peculiar to the kind of fish. Fish size is also important. A large fish consumes less oxygen per unit weight than does a small one. Oxygen levels of water for most warm water fish should be above 5 ppm for normal hauling conditions. This level should prevent oxygen from becoming a major stress factor.

Carbon Dioxide. Like other animals, fish release carbon dioxide as a respiratory waste. The carbon dioxide in the water medium will be in bound form or free form. The bound form is that which enters the buffering system of the water and becomes united with other simple compounds. The free form of carbon dioxide is considered a poisonous waste product. An accumulation of free carbon dioxide must be kept at a satisfactory low level or excess oxygen will be needed to meet fish requirements. Carbon dioxide levels reaching 20 to 30 ppm in transport tanks with air supply cause severe stress. Efficient agitation and bubbling of air through the water will rid it of excess carbon dioxide. Carbon dioxide levels exceeding 30 ppm often are experienced in sealed container shipments but the excess amount of oxygen will allow the fish to overcome respiratory interference (Table 1).

Ammonia. Ammonia is a major waste product of fish that accumulates in poisonous amounts when fish are crowded. Since more ammonia is released at higher temperatures, water temperature is important. Smaller fish will release more ammonia than the larger ones. After release into the water, ammonia may take one of two basic forms: combinable (ionized) ammonia or free (unionized) ammonia. The combinable form will prevail in neutral or acidic water. The free form is poisonous to fish. Unlike carbon dioxide, aeration is ineffective in removal of ammonia because of its strong affinity for water. The large ammonia released by fish in transport water builds up with time. Bacteria use ammonia as a nutrient and as they increase in numbers in the tank water, they partially off-set the rise in the ammonia level during the first few hours of transport.

Among its poisonous effects, ammonia reduces the ability of fish to utilize oxygen and increases the amount of oxygen required. Thus, another variable adds to the demand for availability of adequate oxygen levels during transport.

Temperature. Temperature is important in several ways. Higher temperatures promote a higher oxygen consumption and increase waste release. Carbon dioxide and ammonia are more damaging at higher temperatures. As the temperature of the water increases, its capacity for oxygen decreases. As the temperature increases, there is a decrease in affinity for oxygen by the blood.

Excessive changes in temperature, especially sudden changes, will not allow the body functions of a fish to adjust before severe stress or body changes occur. For most warm water fish, a change of more than 5 degrees should take place over several hours.

Osmotic Balance. Fish have scales and a mucous covering that prevents the exchange of salts and water between their bodies and the water environment. During handling and transport, netting and other events may scrape the covering from the fish and rob them of their protection against salt imbalance.

Over-exertion and Fatigue. When fish are placed in transport containers, they usually exert a large amount of muscular activity. When muscles are actively used, there is not enough blood (thus oxygen) to supply their needs. An alternate system shifts into use where energy is provided in the absence of normal amounts of oxygen. Lactic acid accumulates in the muscles and blood and causes the pH of the blood to drop. Oxygen utilization is reduced by the lower pH of the blood. Following a few minutes of strenuous muscular activity, lactic acid accumulation may not be reduced for 24 hours. Excitability and recovery from the side effects of excietment vary with the species.

Bacterial Populations. As fish enter the transport container, excretory products begin to build up in the water (Figure 5). Bacteria utilize excretory products as food and begin to multiply. Although bacteria are somewhat beneficial in controlling ammonia levels, they may become so abundant that they reduce the oxygen level significantly. This commonly occurs if fish are loaded with their digestive tracts filled with food. If some of the bacteria that populate transport water are potential disease agents or if the fish are particularly low in resistance, bacterial presence may produce disease by directly infecting the fish (Table 2).

Parasites. Protozoan parasites have a special opportunity to multiply on fish when they are held in transport units. For freshwater fish (especially catfish) the protozoan, *Ichthyophthirius*, can massively infest fish during transport. The disease becomes apparent several days after stocking.

Fish Species and Life Stages. The various species of fish cultured in Texas may require transport at a particular life stage. Catfish, for example, may be transported as eggs, fry, fingerlings or adult. Transport precautions are peculiar for each stage. Special precautions are also required for each kind of fish since some species transport easily and others, with unusual fragility.

## MANAGEMENT

Loads and Distances. The objective is to transport fish at a rate in which as many as possible will arrive in good condition. This usually is called the normal or capacity load. The size of such a load varies considerably according to size of fish, hardness of water, species of fish and duration and method of transport. In some cases, a capacity load is not required and the lighter load lessens the risk of detrimental effects.

Since many variables determine the normal or capacity load and there is relatively little research into this problem only a few generalities can be offered. Tables 3 and 4 give loads that are considered slightly light by some fish culturists. The weights given are those that are considered to deliver fish with a measure of safety against predisposal to disease.

As fish weight is increased, a relatively smaller amount of water is present in the transport unit. As wastes increase from the added weight of fish, they accumulate faster because of a smaller volume of water.

Anesthetics. MS-222 (Tricaine methanesulfonate) and quinaldine are the more popular fish anesthetics. MS-222 is advantageous because it is readily soluble in water and quickly affects the fish. Quinaldine is better for sustained sedation but is an oily material which requires some mixing to get into solution. A salt of quinaldine, quinaldine sulfate, recently was produced. It has the same beneficial effects of quinaldine and is easily water soluble.

Anesthetics such as MS-222 or quinaldine are best used to quiet fish during loading. A peak in excitement and maximum lowering of oxygen occur during the first half hour after loading. Sedated fish have their excitement subdued and consume less oxygen during this critical period. It is best to sedate the fish in the holding facility a half hour before loading and then continue exposure to a lower concentration of sedative during transport (Figure 3).

Sedation reduces the possibility of injury, but deep sedation may cause adverse effects by packing or layering of fish. The use of anesthetics should not be relied on for increased load carrying capacity. Other methods are more safe and dependable. The use of anesthetics on food fish that will be consumed soon after exposure is not legal. Consideration should always be given to the legal status of a chemical and possible consequences to the consumer.

Antibacterials and Parasiticides. Antibacterials such as acriflavin neutral nitrofurazone or oxytetracycline supposedly have been used to check the development of bacteria in transport units. As fish begin to release metabolic waste products into the transport water, bacteria begin to flourish (Figure 2).

Commonly used antibacterial additives have been tested in the Extension Fish Disease Laboratory in glass containers loaded with fish that approximated hauling conditions (Table 5). Reduction in bacterial numbers was not notable. Susceptible bacteria were checked and the others continued to multiply. Antibacterials may strengthen the resistance of fish but they are probably of little value as bacterial checks in transport tanks. Rare exception would be in the case where a superficial infection of an antibacterial susceptible bacterium was in progress.

Parasiticides generally are not used in transport systems. Fish are often given a pretransport bath in formalin for elimination of protozoan parasites. *Ichthyophthirius* (Ich) however, will pass through the preventive technique. Ich-infested fingerlings become massively infested when the parasites multiply by the thousands during the transport.

Salts. Sodium chloride (NaCl) and calcium chloride ($CaCl_2$) have been added to holding water to reduce the effects of surface damage. Loss of mucus, scales and external skin allows water to pass into the fish, resulting in disease. Chances for bacterial infection also increase. These detrimental effects as well as multiplication of certain parasitic protozoa, should be curtailed by addition of 0.2% salt (NaCl).

It has been shown that "mixing salt" (NaCl) at a dillution of 0.2% will not harm most fish (including channel catfish).

Other Chemical Additives. Buffers such as "tris-buffer" (tris-hydroxylmethylamino methane) are helpful in controlling pH at a favorable value of 7 to 8. The accumulation of carbon dioxide in bag transport allows for a decrease in pH since carbon dioxide is an acid. Since 10 to 20 grams per gallon of tris-buffer are required to control pH in bags with only moderate loads, the use of tris-buffer in tank transport usually is impractical because of cost. Fish sensitive to low pH such as marine species are most likely to benefit from water buffering.

Agitation or bubbling causes foaming on-water which is heavily laden with organic material (secretions, and excretions, such as mucus and food waste). The foam interferes with oxygen exposure at the water surface. No-foam[1] and other similar compounds reduce or eliminate this problem. Water with NaCl foams less than water without NaCl, but NaCl may interfere slightly with the effectiveness of No-foam (Table 6).

Pretreatment and Loading. The common sequence of events before loading include withholding feed, harvesting, transferring to a holding facility and maintaining fish for a time. Withholding feed allows feed to pass out of the digestive tract. In warmer months, the time required for purging may be one day, whereas in winter, several days may be required. Harvesting and transferring vary greatly according to the conditions, but pretransport maintenance accomplishes several key purposes. Size sorting, species sorting and counting take place during pretransport maintenance. Fish often are given chemical baths designed to prevent disease. Also, the fish empty their digestive tracts and consequently reduce the degree of waste buildup that is possible during transport.

[1]Trade name-Dow Chemical Co.

In areas where surface water is soft, fish fare better in vats receiving a harder ground water. The harder ground water has greater buffering capacity for control of carbon dioxide and, in the warm season, provides a cool water temperature similar to that which will be experienced in transport.

Caution should be taken to avoid temperature shock as much as possible. Where large differences in temperature exist, cooling of the water should be done while the fish are swimming in it. Supersaturation of the hauling water with oxygen before loading prevents oxygen levels from dipping lower than that required for normal function (Figure 4). The water in bag transport and other methods that use bottled oxygen should not have oxygen content reduced beyond the saturation level during the initial loading hour (Figure 5).

Water During Transport. If the transport water is hard, the buffering capacity will reduce the threat of free carbon dioxide excess. In aerated tanks, the exposure of carbon dioxide to air bubbles or agitation is beneficial in reducing free carbon dioxide. The swimming action of fish (particularly in shallow water) causes air exposure and reduces carbon dioxide content.

Ammonia has more affinity to water and, unlike carbon dioxide, aeration techniques do not remove it from water. Reduction of ammonia released by fish and enroute water change are helpful techniques in preventing ammonia buildup. Ammonia release may be curtailed by transport at cooler temperatures. Reduction of loading rate aids in reducing potential ammonia release. Since smaller fish release more ammonia on a weight/water volume basis than large ones, fish size should be considered. Enroute water change should be considered for long deliveries. A pre-established exchange station which has water characteristics comparable with home base water should be selected.

Stocking. Release of fish at the destination can be the most critical stage of the transport process. The fish are under some degree of stress in the transport unit and sudden exposure to water of different characteristics or low quality will further stress the fish, often beyond what they can stand. Poor-quality water may mean "used" water in vats of fish maintenance establishments or freshly pumped ground water with low oxygen or high carbon dioxide content. Different characteristics of water often mean a pH, temperature or gas saturation difference between the transport unit and the receiving water. The harmful effects of different characteristics are eased by gradually mixing new with used water. Gradual mixing of waters that differ greatly will only ease the shock. The fish must be strong enough to take it. The receiving water may be unsuitable for fish life because of pollution or unusual natural characteristics. An inquiry before delivery about the history of fish life in the receiving water is helpful.

Table 1. Water chemistry of bags loaded with various weights of 3-inch channel catfish. Temperature was maintained at 17 degrees C and measurements were made at 24 hours. In contrast to open or tank transport, bags accumulate carbon dioxide because they are sealed. However, the depth of the water in a bag affects buildup of $CO_2$ concentration. Shallow depths allow fish to aerate water by swimming and thus reduce the $CO_2$.

| Amount of Fish in Grams/Litre | Ammonia ppm | Nitrate ppm | $CO_2$ ppm |
|---|---|---|---|
| 25 | 5 | None | 5 |
| 75 | 14 | None | 30 |
| 150 | 21 | None | 55 |

Table 2. Bacteria from blood of fish exposed to various conditions. A loop of blood was removed from kidneys of 6 fish per treatment. Aquaria were used to expose fish to good and poor-quality water. Glass jars with aerated water simulated hauling conditions. Poor-quality water had the following characteristics: $NH_3$ - 8 ppm; $NO_2$ - 2 ppm; $CO_2$ - 10 ppm. The data indicates that transport of fish from poor-quality water is best accomplished if a "pretransport conditioning period" in good-quality water is provided.

| Test Conditions | % of Total Bacteria Isolated From Blood of all Fishes |
|---|---|
| Poor-quality water | 24 |
| Poor-quality water (Hauling conditions 24 hours) | 71 |
| Poor-quality water (Good-quality water 24 hours) (Hauling conditions 24 hours) | 5 |

Table 3. Capacity (normal load in pounds per gallon* of water for tank method transport (with agitators or blower system) of fish in good condition in hard water of 65 degrees F temperature.**

| Size of Fish | Duration of Transport | | | |
|---|---|---|---|---|
| | 1 hr. | 6 hr. | 12 hr. | 24 hr. |
| 2-inch fingerling food fish*** | 2 | 1 1/2 | 1 | 1 |
| > 8-inch fingerling food fish | 3 | 3 | 2 | 1 1/2 |
| 14-inch adult food fish | 4 | 4 | 3 | 2 |
| 2-inch bait fish | 2 | 1 1/2 | 2 | 2 |
| 3-inch bait fish | 3 | 2 | 1 | 1 |

*To obtain kg/l, multiply by 0.12. Load is expressed in pounds of fish/gallon of water.

**For tank method where pure oxygen is supplied instead of agitator-blower aeration, increase load by 25% for each 10 degree F change (warmer) in temperature, decrease load by 25%

***Food fish = catfish, bass, other sunfish, etc.
Bait fish = golden shiner, fathead minnow, goldfish.

Table 4. Capacity (normal) load in grams/litre* of water for bag-oxygen method transport of good condition fish in hard water of 65 degrees F temperature.

| Size of Fish | Duration of Transport | | | |
|---|---|---|---|---|
| | 1 hr. | 6 hr. | 12 hr. | 24 hr. |
| 3-inch food fish fingerlings | 100 | 75 | 50 | 25 |
| 1/4-inch food fish fry | 50 | 40 | 30 | |
| 1-inch bait fish | 100 | 75 | 50 | 25 |
| 3-inch bait fish | 200 | 150 | 100 | 75 |
| 1-inch pet fish | 100 | 75 | 50 | 25 |
| 2-inch pet fish | 100 | 75 | 50 | 25 |

*1 pound = 454 grams. To get pounds per gallon, divide by 120.

Table 5. Chemicals that did not practically retard bacterial numbers in water where test conditions simulated general hauling conditions.

| Chemical | Concentration |
|---|---|
| Nitrofurazone | 0.2 - 80 ppm |
| Salt | 0.2% |
| Methylene blue | 0.1 - 5 ppm |
| Oxytetracycline | 5 - 50 ppm |
| Acriflavin neutral; 5 ppm fish died | 1 - 2 ppm |
| Potassium permanganate | 2 - 5 ppm |

Table 6. Foam production under various conditions in test units that simulated transport conditions.

| Condition | Result |
|---|---|
| Pure water | 5-inch layer |
| No foam | None |
| 0.2% salt added | Thin layer not covering total surface |
| No-foam and 0.2% salt added | Thin layer not covering total surface |

Table 7. Cost (in cents) per fish for transport of a 100 mile distance.

| Cost Per Mile | No. of Fish Carried | | | | | | |
|---|---|---|---|---|---|---|---|
| | 100 | 500 | 1000 | 2000 | 5000 | 10,000 | 50,000 |
| 20 cents | 20 | 4 | 2 | 1 | .4 | .2 | .04 |
| 40 cents | 40 | 8 | 4 | 2 | .8 | .4 | .08 |
| 50 cents | 50 | 10 | 5 | 2.5 | 1.0 | .5 | .1 |
| 60 cents | 60 | 12 | 6 | 3 | 1.2 | .6 | .12 |
| 80 cents | 80 | 16 | 8 | 4 | 1.6 | .8 | .16 |
| 100 cents | 100 | 20 | 10 | 5 | 2.0 | 1.0 | .2 |

Table 8. Conversion factors (Volumes to weights [avoirdupois] are for water)

1 cubic foot = 7.5 gallons = 62.4 pounds = 28,355 grams
1 cubic inch = 16.4 cubic centimeters = 0.004 gallon = 0.016 litre = 16.4 grams
1 gallon = 8.34 pounds = 231 cubic inches = 0.03 cubic foot = 3.785 litres = 3,785 grams
1 pound = 453.6 grams = 16 ounces
1 ounce = 28.35 grams = 437.5 grains = 16 drams
1 dram = 27.3 grains = 1.77 grams
1 grain = 0.065 grams
1 teaspoon = 1 1/3 drams = 36.4 grains = 1/3 tablespoon = 1/6 ounce
1 ppm = 0.0038 grams per gallon = gram in 1,000,000 grams
= 0.028 grams per cubic foot = 1 grain in 1,000,000 grains
= 1 pound in 1,000,000 pounds = .059 grains per gallon

Table 9. Weight/1000 fish in pounds (Data from various sources but mostly from W. Swingle and E. Shell, 1971. Tables for computing relative conditions of some common freshwater fishes. Circular 183, Agr. Expt. Sta., Auburn University 55 pp).

| Fish Length in Inches | Channel Catfish | Blue Catfish | Largemouth Bass | Bluegill Sunfish | Redear Sunfish | Green Sunfish | Carp | Black Crappie | White Crappie | White Bass | Threadfin Shad | Flathead Catfish | Smallmouth Buffalo | Bigmouth Buffalo | Golden Shiner | Flathead Minnow | Goldfish | Red Shiner | Rainbow Trout |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | | 2.8 | 3.5 | 5.0 | 5.4 | 5.2 | 7.6 | 3.7 | 3.5 | | 3.0 | 3.3 | 4.1 | | 3.9 | 3.3 | 5.4 | 2.5 | 3.2 |
| 2 1/2 | 4.6 | 5.4 | 7.0 | 9.8 | 10.1 | 10.1 | 13.7 | 7.2 | 7.0 | 7.8 | 5.8 | 6.3 | 8.1 | | 5.4 | 7.6 | 9.0 | 4.6 | 5.1 |
| 3 | 7.7 | 9.0 | 12.3 | 17.2 | 17.6 | 17.4 | 22.2 | 12.2 | 11.8 | 13.3 | 9.6 | 10.7 | 14.0 | 16.2 | 8.6 | 11.0 | 17.0 | 8.8 | 8.8 |
| 3 1/2 | 12.3 | 14.3 | 19.8 | 28.6 | 27.8 | 27.7 | 33.4 | 19.3 | 19.8 | 20.8 | 14.9 | 16.7 | 22.4 | 25.7 | 13.5 | 19.8 | 24.5 | | 17.6 |
| 4 | 18.3 | 21.0 | 29.7 | 41.4 | 41.1 | 41.3 | 47.4 | 28.6 | 29.6 | 31.0 | 21.8 | 24.6 | 33.7 | 38.3 | 19.0 | 24.4 | 40.0 | | 25.6 |
| 4 1/2 | 26.0 | 29.9 | 42.9 | 59.5 | 58.2 | 59.9 | 64.6 | 40.6 | 42.4 | 44.3 | 29.9 | 34.6 | 48.2 | 54.2 | 31.5 | 28.3 | | | 35.0 |
| 5 | 35.2 | 40.7 | 59.0 | 82.4 | 79.5 | 81.9 | 85.0 | 55.7 | 58.4 | 60.6 | 40.3 | 46.9 | 66.3 | 74.2 | 44.0 | | | | 63.9 |
| 5 1/2 | 46.9 | 53.7 | 78.8 | 110 | 106 | 109 | 109 | 73.9 | 78.2 | 80.5 | 52.2 | 61.9 | 88.6 | 98.3 | 60.0 | | | | |
| 6 | 60.5 | 69.8 | 103 | 144 | 136 | 141 | 137 | 95.6 | 102 | 104 | | 79.3 | 116 | 127 | | | | | 104 |
| 6 1/2 | 76.4 | 88.1 | 132 | 185 | 173 | 179 | 167 | 121 | 130 | 132 | | 100 | | | | | | | |
| 7 | 95.2 | 110 | 165 | 234 | 215 | 223 | 206 | 151 | 163 | 165 | | 139 | | | | | | | 174 |
| 7 1/2 | 117 | 134 | 204 | 286 | 264 | 273 | 247 | 186 | 200 | 203 | | 152 | | | | | | | |
| 8 | 141 | 162 | 248 | 352 | 320 | 331 | 293 | 228 | 245 | 246 | | 183 | | | | | | | 218 |
| 8 1/2 | 168 | 194 | 299 | 416 | 383 | 396 | 344 | 269 | 295 | 294 | | 218 | | | | | | | |
| 9 | 199 | 229 | 354 | | 453 | | 399 | 321 | 351 | 349 | | 257 | | | | | | | 328 |
| 9 1/2 | 233 | 269 | 420 | | 532 | | 460 | 375 | 414 | 410 | | 303 | | | | | | | |
| 10 | 272 | 312 | 491 | | 619 | | 527 | 436 | 484 | 478 | | 350 | | | | | | | 449 |
| 11 | 376 | 414 | 657 | | | | 677 | 573 | 648 | 635 | | 471 | | | | | | | 535 |
| 12 | 501 | 532 | 857 | | | | 851 | | 845 | 823 | | 618 | | | | | | | 681 |
| 13 | 654 | 680 | 1094 | | | | 1050 | | 1078 | 1045 | | 801 | | | | | | | 868 |
| 14 | 834 | 872 | 1373 | | | | 1276 | | 1351 | 1303 | | 1014 | | | | | | | 1086 |
| 15 | 1048 | 1100 | 1695 | | | | 1574 | | 1668 | 1610 | | 1263 | | | | | | | 1330 |
| 16 | 1297 | 1366 | 2073 | | | | 1903 | | 2031 | 1940 | | 1558 | | | | | | | 1674 |
| 17 | 1585 | 1674 | 2484 | | | | 2296 | | | 2324 | | 1880 | | | | | | | 2049 |
| 18 | 1914 | 2029 | 2958 | | | | 2747 | | | | | 2255 | | | | | | | 2335 |
| 19 | 2288 | 2433 | 3490 | | | | 3233 | | | | | 2678 | | | | | | | 2910 |
| 20 | 2709 | 2891 | 4082 | | | | 3776 | | | | | 3152 | | | | | | | 3267 |
| 22 | 3183 | 3414 | 4738 | | | | 4401 | | | | | 3717 | | | | | | | 3634 |

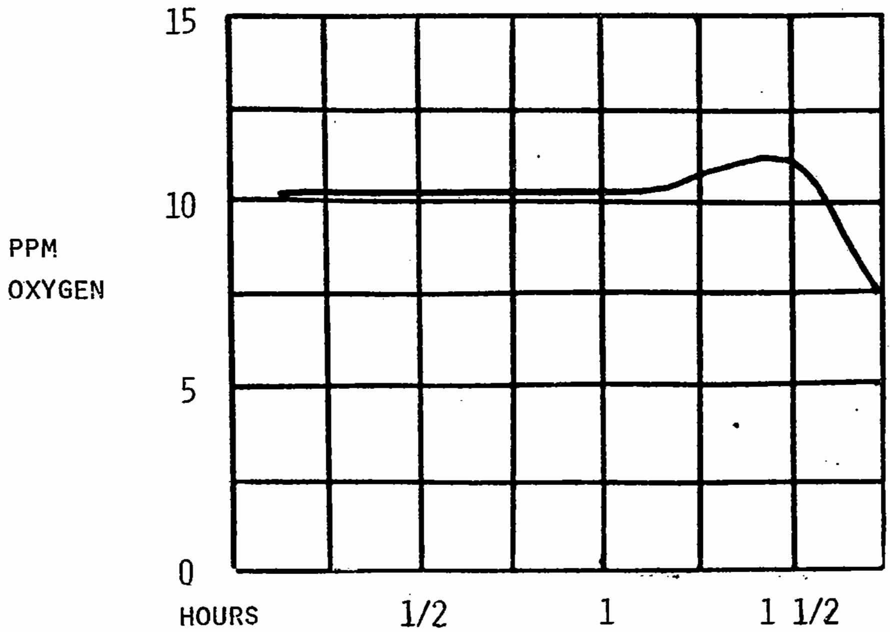


Figure 1. Oxygen concentration during the first hour and a half of the water in the test containers that simulated loading and transport conditions. Oxygen concentration drops to a certain level and then increases again. The initial drop in oxygen content may be too low to meet that required by the fish.

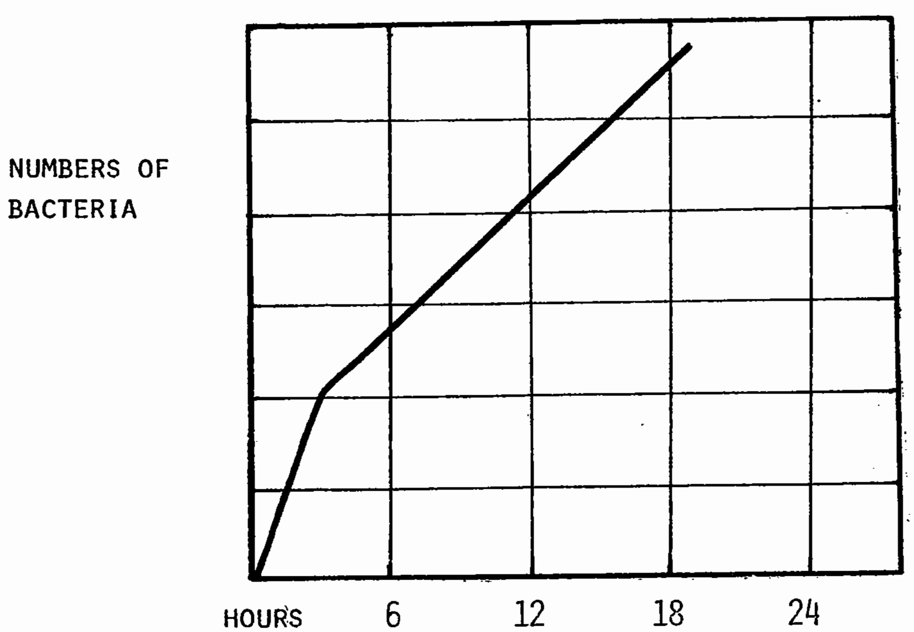


Figure 2. Increase of bacteria in water of test containers that simulated hauling conditions.

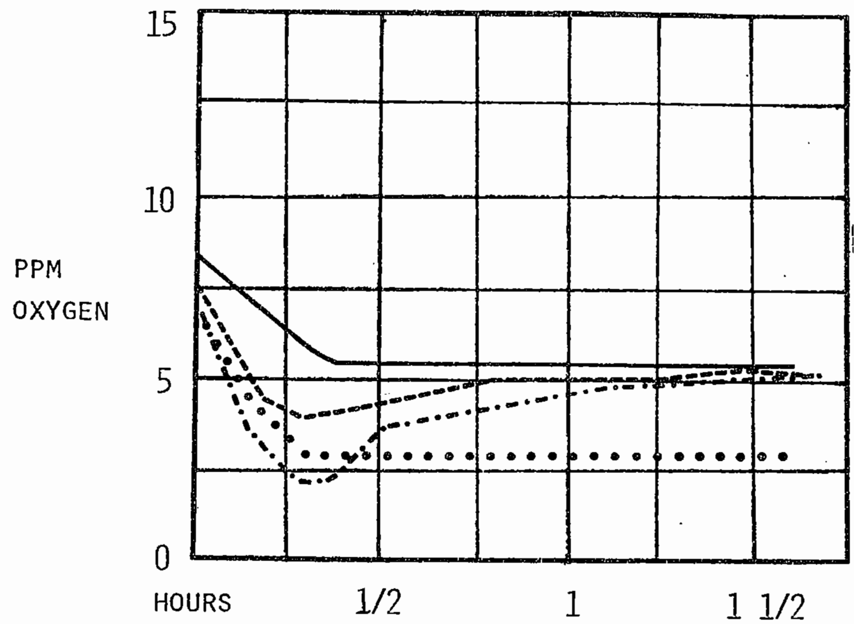


Figure 3. The use of anesthetics to off-set the initial drop in oxygen concentration experienced in the period following loading (test conditions simulated actual transport conditions).

Various test conditions and results were:

Water only (dash line) — Resulted in the usual drop and increase.

5 ppm quinaldine added to water (dot-dash line) -- Resulted in fish becoming extra excited by the chemical and the oxygen dropped very low.

Fish sedated in 20 ppm quinaldine and then added to pure water (dotted line) -- Resulted in the oxygen dropping low as the fish came out of sedated state.

Fish sedated in 20 ppm quinaldine and then placed in 5 ppm quinaldine for observation (solid line) resulted in no dip in oxygen below a "safe" concentration.

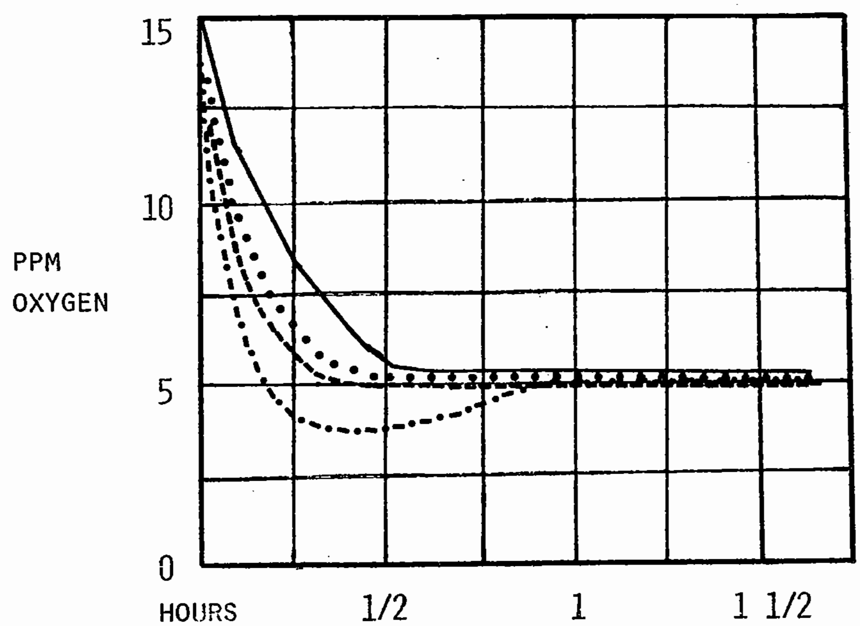


Figure 4. Supersaturation of transport water with oxygen prior to addition of fish. The various test conditions presented in Figure 3 were also used in this test. Those were: water only (dash line); 5 ppm quinaldine (dot-dash line); sedated fish into water (dotted line); sedated fish in 5 ppm quinaldine (solid line). The results indicate that supersaturation of water prior to fish addition is sufficient to off-set the post loading low oxygen concentration without the use of anesthetics.

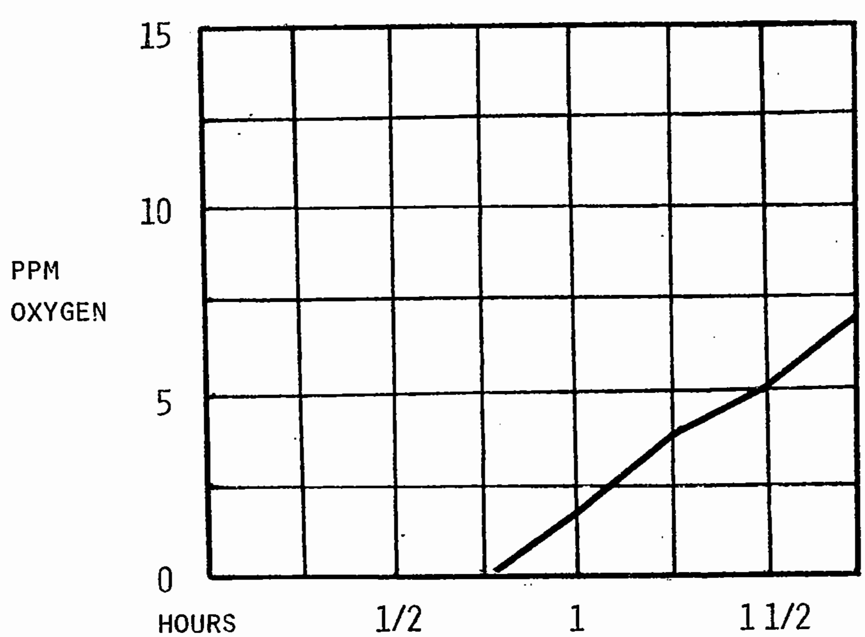


Figure 5. Oxygen was monitored for the first hour after bagging fish. Water, fish and oxygen were added in the usual fashion and normal weights of fish used. As can be seen from the graph; the water becomes supersaturated steadily and does not go below saturation as a result of the time required for oxygen and water to undergo exposure.

Testing Aids. Since the quality of the water is critical in fish transportation, monitoring of several conditions will aid the transporter. An oxygen meter is helpful. Many fish transporters keep an oxygen meter in the cab of their truck and extend a lead back to the tanks. Oxygen meters have become popular with fishermen in recent years and as a consequence may be purchased at a relatively low cost. There are meters available to test pH but the use of universal indicator solution is more economical. Universal indicator may be used to compare pH change between beginning and ending transport water or truck tank and receiving water. Universal indicator solution is available from most scientific chemical companies and indicates pH by a change of colors between a pH range of 4 to 11. Ammonia may be tested by the use of Nessler's reagent (also available from most chemical companies). Nessler's reagent gives a color reaction in the presence of ammonia which becomes a darker yellow as amount of ammonia increases. Tests with universal indicator and Nessler's reagent are conducted by adding a drop of test fluid to the water sample. Carbon dioxide content may also be monitored by using one of several inexpensive test kits which are commercially available.

Other Considerations. Tables 7, 8 and 9 give data on cost of transport, converstion of measurements and fish weight. The data of Table 9 is based on total length. Since there is variation in weight of fish of a particular length, the data is given for comparative purposes only.

Displacement of water by fish should also be considered because the specific gravity (ratio of weight to volume compared to water as a standard value of one) of a whole fish varies according to size and species. As an example, water weighs 8.54 pounds per gallon but 8.54 pounds of a particular fish may displace more than a gallon of water.

Research information on displacement according to species is unavailable at this time. The fish farmer could measure displacement and derive a set of displacement numbers that are suitable for his particular fish. To do this an amount of water equal in weight to that of a group of fish is loaded and the depth measured again. The fraction of depth that doesn't equal twice that of the water alone is used to establish a numerical value for displacement of volume.

FURTHER READING:

Fry, F. E. J. and K. S. Norris, 1962. The transportation of live fish in "Fish as Food" (G. Borgstrom, Ed.) Vol. 2, pp 595-608. Academic Press, New York.

Norris, K. S. , F. Brocato, F. Calandrinn, and W. M. McFarland. 1960. A survey of fish transportation methods and equipment. California Fish and Game 46:5-33.

U.S. Fish and Wildlife Service. 1978. Manual of Fish Culture, Section G:

# IMPORTANT FACTS ABOUT TRANSPORTING LIVE FISH

By Daniel J. LaPlant
Soil Conservation Service, Buhl, Idaho

1. The objective is to transport as many fish as possible in as little water as possible with as little loss as possible and as economically as possible.

2. For best results, use spring water with high alkalinity and relatively high hardness.

3. When hauling in plastic bags, use 3 mill bags for fry and fingerlings and double 4 mill bags for fish with spines.

4. Keep plastic bags in styrafoam boxes or styrafoam lined cardboard boxes to control temperature.

5. Use a small ambulance oxyten bottle to inflate plastic bags after fish and water are in place.

6. Seal bag with tape or rubber band.

7. A 1 mill bag can be used for small amounts of small fish without oxygen because it is semi-permeable allowing gases to exchange through the walls of the bag.

8. Best results are obtained when fish are shipped in a wide, shallow bag. (One layer of fish covered with water.)

9. Fishermen use aspirin in their minnow buckets to control bacteria and maintain good water quality.

10. Add ice to keep water cool, 40° to 45° F for trout, 55° to 65° F for warm-water fish.

11. Cool water: slows fish metabolism and allows them to use less oxygen, controls bacteria, controls $CO_2$ and toxic ammonia, and allows water to hold more oxygen.

12. One half pound of ice/gallon of water reduces water temperature by about 10° F.

13. For plastic bag hauling, place ice in separate bag and place on top of catfish but under or next to other fish.

14. Fish misplaced or lost in shipment don't stay lost for long. The terrible odor in a few days usually makes the mistake easy to locate.

15. Eliptical or V-shaped tanks promote better mixing of water.

16. Oxygen can be liberated into tanks by way of:

    a. perforated rubber tubing
    b. aquarium and carborundum stones
    c. carbon rods
    d. micropore tubing

    Oxygen released through large holes (large bubbles) will not be absorbed into the water and will not benefit the fish. Small holes are most desirable.

17. Pumps used in circulating systems on transport tanks can increase water temperature of 400 gallon by 7° F per hour.

18. Filtration of water in a circulating system removes loose fish scales, mucus, regurgitated food and fecal material. It also reduces foaming.

19. Fish loads (either numbers or weight of same size fish) can be increased by 25% if pure oxygen is used instead of agitators or blowers.

20. Anesthetics like MS-222 or quinaldine are not legal for use on food fish if they are to be consumed within 21 days.

21. Starve small fish 2 days before shipment - fish larger than 40/lb. starve 3 days - fish larger than 4/lb. starve longer.

22. Do not starve cannibalistic species such as L. M. bass.

23. If you add water during shipment, it should be of the same characteristics as the water you started with.

24. Release of fish at the new destination is very critical - slowly mix transportation water with receiving water to aclimatize fish to the temperature and chemical differences.

25. Delayed mortality may exist due to buildup of lactic acid during transport.

26. Hypothermia (keeping cool) is the best method of preventing buildup of lactic acid during transport.

27. Aeration will prevent $CO_2$ buildup. $CO_2$ can interfere with the oxygen affinity to the blood.

28. Fewer pounds of small fish per gallon of water can be transported than larger fish.

29. Carrying capacity of fish in a given tank is directly proportional to their length.

Example: If a tank will hold 1000 lbs. of 10" fish it will hold:

1000 X .5 = 500 lb. of 5" fish
or
1000 X .3 = 300 lbs. of 3" fish
or
1000 X 1.2 = 1200 lbs. of 12" fish

(If all other conditions remain the same, the capacity decreases 5.6% for each 1° F increase and increases 5.6% for each 1° F decrease.)

30. Fish require more oxygen when they are subject to sudden changes in temperature.

31. Trout kept in 34° F water excrete less toxic ammonia.

32. For 5-8 lb. cat fish, wrap and tie a single fish in wet muslin and ship it in an oxygen inflated plastic bag without water.

33. Trout transporting - Under ideal conditions, the maximum load of catchables (2-5/lb.) is 2.5 - 3.5 lbs/gallon of water for 8-10 hours of transport. (For 8-10" trout, transport 12 fish per gallon.)

34. Bass transporting - Ship at 1-3 days old, 3000 fry/liter of water in a square bottomed plastic bag 38 x 38 x 56 cm with 7.57 liters of water.

Pounds of bass and other panfish that can be transported per gallon of water at 65° - 85" F for less than 16 hours.

| Weight of Fish (No./pound) | Length (in.) | No. of fish/gallon | Lbs. of fish/ gallon |
|---|---|---|---|
| | 6-10 | | 2.0 |
| 25 | 4 | 25 | 1.0 |
| 100 | 3 | 67 | 0.6 |
| 400 | 2 | 200 | 0.5 |
| 1000 | 1 | 333 | 0.3 |

35. Catfish transport:

Pounds of channel catfish that can be transported per gallon of water at 65° F for less than 16 hours.

| Weight of Fish (No./pound) | Number of Fish/gallon | Pounds of Fish/gallon |
|---|---|---|
| 1 | 4.8 | 4.8 |
| 2 | 7.0 | 3.5 |
| 4 | 12.0 | 3.0 |
| 50 | 100.0 | 2.0 |
| 125 | 225.0 | 1.8 |
| 250 | 375.0 | 1.5 |
| 500 | 625.0 | 1.25 |
| 1000 | 700.0 | 0.7 |
| 10000 | 2000.0 | 0.2 |

LITERATURE CITED:

D. C. Greenland, 1974, Recent Developments in Harvesting, Grading, Loading and Hauling Pond Raised Catfish. ASAE Vol. 17, No. 1, pp 59-66.

A. H. Hulsey, 1962, Transportation of Channel Catfish Fry in Plastic Bags. Sixteenth Annual Conference Southeastern Association of Game and Fish Commissioners - 1962.

S. K. Johnson, 1979, Transport of Live Fish. Texas A&M University FDDL-F14.

M. Martin, 1980, Plastic Bag Hauling of Small Live Fish, Parts 1 and 2. Aquaculture Magazine Nov-Dec/80 and Jan-Feb/81.

U.S. Fish and Wildlife Service, 1978, Manual of Fish Culture - Fish Transport, Sec. G.